AN ASSESSMENT OF PESTICIDE RESEARCH PROJECTS

Funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee

1979 - 1980

Ontario

The Ontario Pesticides Advisory Committee

Date Due

AN ASSESSMENT OF

PESTICIDE RESEARCH PROJECTS

FUNDED BY

THE MINISTRY OF THE ENVIRONMENT

THROUGH

THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1979-1980

PESTICIDES ADVISORY COMMITTEE

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* Retired during March, 1980 and succeeded as Chairman by Dr. G. S. Cooper.

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RESEARCH PROJECTS FUNDED THROUGH THE ONTARIO PESTICIDES ADVISORY COMMITTEE

1979-80

I SUMMARY

1) In 1979-80, the Ontario Pesticides Advisory Committee continued a program, begun in 1973, of funding research on pesticides. The objectives of the program are:

   a) To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

   b) To determine potential environmental hazards with pesticides currently in use.

   c) To reduce pesticide input into the environment.

2) Forty-five research proposals totalling $679,230 were received.

3) Twenty-six research proposals were funded with a total value of $296,775. Awards averaged $11,414 and ranged from $1,875 to $51,000.

4) Eleven grants totalling $111,875 were awarded for studies on development of alternative pesticides for pest control.

5) Seven grants totalling $58,600 were allocated to studies on the behaviour and fate of pesticides in the environment and on potential environmental hazards to non-target organisms.

6) Eight grants totalling $126,300 were allocated for studies aimed at reducing pesticide input into the environment, while still achieving effective pest control.

7) The Pesticides Advisory Committee is very satisfied with the research progress made in 1979-80. It recognizes that with the limited funds available the program of grants can be expected to act only as a catalyst in stimulating research in the broad areas indicated in the Committee's guidelines for which there is still an urgent requirement.

II. RECOMMENDATIONS

The Pesticides Advisory Committee recommends that:

1) The Ministry of the Environment continue to support research programs directed toward development of pest control programs which will not pose any serious environmental hazard.

2) The Pesticide Advisory Committee continue to supervise this program following guidelines which have been developed.

III. REVIEW OF THE RESEARCH PROGRAM

The Ministry of the Environment first allocated funds to the Ontario Pesticides Advisory Committee to sponsor pesticide-related research in 1973. Results have been summarized in Annual Reports (OPAC 1974-79, incl.). A five year assessment of progress was included in the 1978 report. Results obtained have encouraged the committee to recommend that the research program be continued under its supervision and the committee is gratified that this recommendation has been accepted. In 1978, two other research programs receiving short-term funding from the Ministry of the Environment were placed under supervision of the Advisory Committee. Support for one program (Guelph Arboretum) terminated in 1979. The combined budget for the normal OPAC research program and the other project on blackbird population management was $300,000 in 1979-80.

Terms of reference developed by OPAC to govern the awarding of research grants are based on three objectives, i.e., the need to find suitable replacements for pesticides deemed hazardous and restricted for use in Ontario; the need to determine if pesticides in use pose any serious environmental hazard; and the need to develop more effective approaches to pest control leading to a reduction of pesticide input into the environment. The "Application for Research Support" (Appendix I) invited proposals in six broad areas relating to these three objectives. Invitations for applications for research support were widely distributed in January, 1979 to personnel in Ontario universities, industry, and government (copies of the mailing list are available on request), with deadlines for applications being February 28, 1979.

Forty-five research proposals totalling $679,230 were received. Most (39) were from universities (Brock, Carleton, Guelph, Ottawa, Toronto, Waterloo, Western). Six applications were received from industry or other organizations. (A list of titles of research proposals submitted for consideration by OPAC is available on request).

Applications were considered first by the research Subcommittee (P. D. Foley, C. D. Fowle, R. Frank, D. N. Huntley, F. L. McEwen, G. R. Stephenson, D. W. Wilson, and C. R. Harris (Chairman)) and then by the Advisory Committee. Twenty-six proposals were accepted, valued at $296,775. Awards averaged $11,414 (range $1,875-$51,000). Most of the grants were awarded to individuals at universities. Disbursement of research funds by organization is summarized below:

Organization	No. research grants awarded	Total research funds ($)
University of Guelph	16	226,800
University of Western Ontario	4	26,800
University of Waterloo	2	18,800
University of Ottawa	1	14,000
Carleton University	1	1,875
Other	2	8,500
	26	296,775

Direction and progress of the research program were monitored by the Advisory Committee in several ways. Initially some applicants were asked to modify their proposals to better meet the research guidelines. Informal contacts between the research sub-committee and some recipients of grants were established. In January 1979, OPAC sponsored a two-day research seminar at which recipients of grants discussed their research results. This meeting was attended by Advisory Committee members and >80 people interested in pesticide-related research. Each recipient of a grant provided OPAC with a summary of results (Appendix III). Published research reports relating to research sponsored by the Pesticides Advisory Committee are listed in Appendix IV.

Progress made in 1979-80 relative to the objectives of the program may be summarized as follows:

Objective 1: To find alternative pesticides for those deemed environmentally hazardous and thus restricted in use.

In the past decade environmental concerns have resulted in restrictions on the use of some pesticides in Ontario, particularly those which were persistent. Usually alternative chemicals were available. In some instances no alternatives to the use of persistent pesticides were feasible; or the alternative approaches to pest control were not satisfactory; or the substitutes presented their own special hazard, e.g. the high mammalian toxicity of some organophosphorus (OP) insecticides. In these cases, OPAC has funded research aimed at developing satisfactory methods of pest control. Eleven grants were awarded under this objective in 1979-80 totalling $111,875.

Biting flies are "nuisance pests" and disease transmitters. In 1979-80 continued emphasis was placed on studies on the biology and control of biting flies in Ontario. More information was obtained on the biology of two important species of Culex mosquitoes. A technique was devised for monitoring populations of Culex spp. and work was initiated on development of an inexpensive method of mapping breeding sites of spring Aedes spp. populations using aerial infra-red photography. In control studies: the experimental insect growth regulator Bay SIR 8514 and sorbitan monooleate showed promise for control of mosquito larvae; tests with temephos indicated that recommended dosages should provide satisfactory control of all stages of Aedes spp. larvae under conditions encountered in Ontario; the pyrethroid insecticides, especially cypermethrin, showed promise for control of mosquito larvae and pupae, while permethrin was effective for backyard mosquito control; and while granular repellents provided temporary relief from mosquito attack, a "lawn-stick"repellent was ineffective (22)*. Promising results were obtained in a study to determine the feasibility of using a biological technique to control mosquitoes breeding in catch basins. Introduction of a native Planarian

* Numbers in brackets refer to Abstracts included in Appendix III.

flatworm resulted in significant reductions in mosquito larvae (9). In blackfly studies, laboratory and field tests were continued with the aim of finding effective, safe, economical methods of chemical control. The insect growth regulator, diflubenzuron, gave encouraging results. A microencapsulated formulation of chlorpyrifos-methyl, while effective, was considered unsafe to non-target organisms (11).

Although it is not generally realized by the public, structural-household pests are of major concern in Ontario and large quantities of pesticides are used to control them. Termites are becoming a serious problem in some urban areas and the only effective control measures require use of persistent organochlorine (OC) insecticides. Development of alternative control programs will be dependent to a considerable extent on obtaining a better understanding of termite biology under local conditions. A two-year study provided a considerable amount of useful data on the life history and behaviour of field-dwelling termite colonies at three locations in southwestern Ontario. Results indicated that: the termite population is well-adapted to the southern Ontario climate; it may be able to adapt to more rigorous conditions, and extend its range further northward; it is unlikely that termites can be eradicated from Ontario, which should be considered by urban planners when preparing building codes (16). A second study on termites was initiated to determine if it was feasible to produce fungal bait blocks on a relatively large scale for use as baits in termite monitoring and control programs. Preliminary results suggest that the time required for production cannot be reduced significantly but, depending on the fungus and type of wood used, improved production efficiency might be possible (21). Cockroaches in buildings are both nuisance pests and a potential health hazard. They are difficult to control and have developed resistance to insecticides in many places. No baseline data are available on the susceptibility of cockroaches to insecticides in Ontario. In a study begun in 1979, baseline toxicity data were obtained using German cockroaches and several insecticides commonly used for cockroach control. Comparison of results obtained with an insecticide-susceptible strain and a strain started from collections made from apartment buildings in Toronto indicated that the Toronto strain showed low level resistance to several insecticides, particularly diazinon (2). Bat control remains a controversial problem in Ontario and DDT is still used, in some instances, for this purpose. A study begun in 1978 suggested that the primary means of bat control should involve sealing access holes to buildings used by bats. This approach is not always feasible and further studies were done in 1979 to assess the effectiveness of other control agents. Three chemicals and two ultrasonic repellers were tested. None proved suitable for bat control (7). A study on development of insecticidal baits for earwig control was begun. Progress was made in developing a laboratory rearing procedure (14).

Several projects were initiated or continued relating to control of pests of agricultural crops. The cabbage maggot is an important economic insect pest in Ontario. It developed resistance to OC insecticides and relatively large amounts of OP and carbamate

insecticides must be applied to achieve a satisfactory degree of control. In the second year of a study to determine optimum combinations of insecticides and nutrient baits that could be used to attract the adults, laboratory baseline toxicity data were obtained for several insecticides which were highly toxic to the flies, and the effectiveness of several nutrient bait-insecticide combinations was determined. The laboratory tests indicated that the approach might have potential. In later field tests the addition of baits to the insecticide sprays appeared to increase the efectiveness of the spray (20). Another agricultural problem, bacterial speck, is affecting processing tomatoes grown in southwestern Ontario. Current control programs rely on heavy use of copper sprays. Two research projects were funded. In one, field plots were treated with various copper fungicides, dithiocarbamate fungicides, and combinations thereof. Seven applications of fixed coppers totalling 15.2 and 30.8 kg/ha provided adequate control of bacterial speck. Maneb and mancozeb were ineffective when used alone, but each enhanced control when used in combination with fixed coppers (5). In a related study, observations made on commercial tomato cultivars and materials used in breeding trials indicated a considerable range in susceptibility to bacterial speck. Greenhouse and field trials indicated that a number of cultivars are resistant to this disease, suggesting that development of bacterial speck-resistant varieties of tomatoes may be feasible (12).

Objective 2: To determine potential environmental hazards with pesticides presently in use.

Seven grants totalling $58,600 were allocated to this objective. Results of an earlier study are included here also.

Research on the fate of pesticides in the environment was continued. Tests conducted over three years to examine the persistence in soil of granular treatments of several OP and carbamate insecticides used for onion maggot control indicated that, when applied at recommended application rates, residues of ethion, fonofos, chlorpyrifos, chlorfenvinphos, and carbofuran were not accumulating in organic soils. No significant levels of insecticide residues were found in onions grown on the treated soils. Field studies on the persistence of four pyrethroid insecticides in mineral and organic soils were continued. The pyrethroids disappeared relatively quickly from mineral soils, but with organic soils, both surface and incorporated treatments were more persistent (27). In a related study, laboratory tests indicated that microbes degrade pyrethroid insecticides in soil (25). While environmental contamination from use of mercurial pesticides is minimal in Ontario when compared to industrial mercury pollution, the mercurial pesticides have been replaced when feasible. They are, however, still used to control snow mold on fine turfgrass. Data obtained in 1978 indicated that, while several experimental compounds showed promise for snow mold control, only the mercurial fungicides gave consistently good results. In the second year of this study emphasis was placed on determining the fate of mercury applied to turfgrass. Two sites with a long history

of mercury use were sampled. Preliminary results suggest that the bulk of the mercury residue remains in the thatch and upper layer of the soil, but that some vertical and lateral movement can occur (8). Research on the fate of herbicides in the environment was continued. The three major soil metabolites of glyphosate were identified and the microbial degradation of the four compounds was examined. Studies were continued on the transformations undergone by aniline-based herbicides (3). In laboratory tests, parameters influencing the rate of loss of diquat were determined and used to develop and test a simulation model for diquat persistence under various conditions. Using this model, small scale field tests were done. Results indicated that the diquat model was appropriate, and applicable to further field trials on the persistence of diquat and other herbicides in aquatic systems (13).

The potential of pesticides to affect non-target terrestrial and aquatic organisms received further attention. Techniques for assessing specific effects of pesticides on soil processes are time consuming and laborious. A three year study to assess the feasibility of developing a technique for assessing non-specific effects of pesticides on soil processes, such as litter decomposition, was completed. This "litterbag" technique involves burying nylon fabric bags of different mesh sizes, which exclude soil invertebrates of different size classes, in soil. The bags contain leaf tissue, e.g. corn leaf, and the rate of decomposition can be measured through the year. Using this technique, carbofuran had only limited short-term effects on the litter decomposition process. A cost/time analysis of the litterbag method versus the soil core method showed that the former allowed simplified data analysis and interpretation, and required minimal taxonomic expertise compared to soil core analysis. The litterbag technique appears to be a practical approach to assessing pesticide effects on the decomposition process in soil (24). In another study, solvent-pesticide interactions were determined for two fungicides and an insecticide with acetone using two test organisms. Effects were additive, synergistic, or antagonistic depending on the combinations tested, indicating that solvent-pesticide interactions must be determined to obtain a true evaluation of toxicity. In related work, the response of a blue-green alga to combinations of mercuric, cadmium, and nickel ions was determined. Effects on photosynthesis, nitrogenase activity, and growth were additive, synergistic or antagonistic depending on the order of metal addition and concentrations used (3). Studies on the effect of pesticides on the rheotropic response of rainbow trout were continued. Pentachlorophenol affected behaviour of the fish at lower concentrations and killed them at 0.3 ppm. Several herbicides were tested. None caused death at the concentrations tested, but they did affect behaviour. 2,4-D-butoxyethanol ester and 2,4-DP showed a similar effect when used singly, but in combination they caused marked changes in behaviour and many of the fish died at the higher concentrations tested (4).

Investigation of the degree of pain and distress caused to vertebrate pests on exposure to pesticides used to control them was continued. Several vertebrate pesticides were tested. Most acceptable results were obtained with the anticoagulant group of pesticides, particularly the newer short-acting anticoagulants. Red Squill, zinc phosphide, and Vacor were not considered acceptable (19).

Objective 3: To reduce total pesticide input into the environment.

Eight grants totalling $126,300 were allocated to this objective.

Pesticides are often applied as "insurance treatments", i.e. the grower is not sure that the pest will be present at a level high enough to cause serious damage, but cannot afford to take the risk that this will occur. Thus it is important to determine economic thresholds of damage below which pesticide application would be unnecessary. A study, begun in 1978, to determine the economic significance of potato leafhopper damage to alfalfa in Ontario was continued. Field tests conducted at several locations indicated that leaf hoppers could reduce alfalfa yield markedly. Cost/benefit analysis indicated a return of four and eight dollars/acre for methoxychlor and dimethoate, respectively, for each dollar invested (6). A new project was begun to determine the costs and potential benefits of pest monitoring programs on onions and carrots in the Holland Marsh. Production costs are being determined and these data will be used to assess the impact that pest management can have on the costs of producing onions and carrots (17). Crop loss studies conducted at the Thedford Marsh indicated that, in the absence of insecticide treatment, potential crop loss due to onion maggot would be 16, 538, and $591/acre for Dutch Sets, pickling onions, and sets for seed, respectively (23). In another study, begun in 1979, an attempt is being made to determine an economic threshold for the tentiform leaf miner through measurement of the effects of leaf miner feeding on the physiology of the apple leaf. Preliminary results indicate that the apple tree can compensate for damage caused by low numbers of leaf miners, but higher populations have detrimental effects (18).

Development of effective pest monitoring techniques would often result in a reduction in pesticide use, i.e. with pesticide applications timed to the appearance of the pest there would be no requirement for "insurance applications." The Advisory Committee has supported projects of this nature for a number of years and continued to do so in 1979-80. Work was continued at the Keswick, Holland, and Thedford Marshes. At the Keswick and Holland marshes, where the research is most advanced, previously separate monitoring programs for insects and diseases of carrots and onions were combined. This monitoring program was successful in decreasing pesticide input without sacrificing yield and quality of the products. In addition, further research was

done relating to the timing of fungicide applications to control Botrytis leaf blight and downy mildew on onions (15). At the Thedford Marsh emphasis was placed on monitoring for onion maggot. Proper timing of spray applications provided effective control of heavy onion maggot populations. Also, field trials were conducted to evaluate insecticides currently recommended for onion maggot control as well as several experimental insecticides (23). With vertebrate pests, biological studies of blackbirds were continued to provide background information necessary if population management is to be implemented. Research completed in 1979 included: continuation of studies on the local blackbird population in the Matchedash Bay area; establishment of baseline data for an environmental impact assessment of roost control should it be forthcoming; and assessment of the feasibility of population control by the use of toxicants at foraging sites (10).

Pesticide application techniques are crude and only part of the pesticide applied actually reaches the target. More efficient application techniques would result in better pest control with less environmental contamination. The Advisory Committee has funded several studies leading to development of better application techniques previously. Research on development of an electrostatic sprayer, funded over five years by OPAC, is currently being supported by Agriculture Canada on a greatly expanded scale. In 1979, a new proposal to compare herbicide application methods using three new sprayer designs was supported. Results of this study will be reported later (1).

Non-chemical methods of pest control may be practical in some situations. One approach, widely advocated by organic gardeners, is to use companionate plantings. There is, however, little actual scientific data to verify claims that this approach to pest control is effective. A study to evaluate the effect of companionate planting on pests in the home garden was initiated in 1979. Results obtained in the first year of this study failed to substantiate popular claims that companion plants repel insects and disease organisms (26).

ASSESSMENT

Within the first research objective, good progress is being made on biting fly control. Information on important species of mosquitoes is being developed; techniques for locating breeding sites and monitoring development of mosquito populations are being devised; and effective chemical control programs for biting flies are being worked out. Development of integrated techniques for management of biting flies will take much longer, but the possibility of using a biological control agent to suppress mosquitoes breeding in catch basins is encouraging. By contrast, with some other pest situations some major problems remain. For example, problems associated with control of structural and household pests are becoming more and more apparent. Projects supported by the Advisory Committee over the past few years have begun to provide some information on biology and

control of some of these pests. Nevertheless, it is obvious that our knowledge of the biology of pests, such as termites, is inadequate; that there are few alternatives to the use of persistent pesticides, such as chlordane, to control them; and that the options will be even more limited as pests like cockroaches develop resistance. Similar problems exist with agricultural pests. It is obvious that continued emphasis will have to be placed on development of less persistent, less hazardous chemicals, and of integrated methods of control for important structural, household, and agricultural pests.

Under the second objective, good progress has been made in the last few years in defining the behaviour and fate of insecticides in the environment. OC insecticides are declining in agricultural soils in Ontario, and residues of OP and carbamate insecticides are not accumulating in mineral soils to any significant extent. Results of studies in 1979-80 and earlier suggest that the effects of insecticides currently in use on non-target soil microorganisms and invertebrates will be transitory. As far as can be determined with techniques currently available, most vertebrate pesticides act within acceptable limits of pain and distress when used in control programs. There are some other areas of major concern. Organic soils are important agriculturally in Ontario, with the vegetable crops produced on them being worth about $30,000,000/year. Pesticides are used extensively on these marshes and studies on insecticides over the last few years indicate that residues are present in soil, water, and air. Good progress has been made in defining the insecticide residue situation in these organic soil areas, and in developing less persistent insecticides and pest monitoring programs for control of the major insect pests. These approaches will ultimately lead to a decline in insecticide residues in organic soils. The picture as regards herbicides and fungicides, which also are used extensively on organic soils, is less clear and more research is required on the persistence, behaviour and fate of these chemicals in the soil environment. Similarly more research is justified on herbicide persistence and behaviour in the aquatic environment.

The Pesticides Advisory Committee feels that priority should be assigned to the third research goal, i.e. of reducing pesticide input into the environment while still achieving as good as or more effective pest control. Good progress is being made in developing crop loss data, economic thresholds of damage, and pest monitoring techniques. Such studies, as well as research on better methods of application and integrated pest control merit strong support.

The Pesticides Advisory Committee is pleased with the research progress made in 1979-80 and recommends continuation of the program. Part of the success of the program is due to the fact that it has been deliberately kept small allowing committee members, all of whom have other full-time responsibilities to administer it with a minimum of effort. The Committee feels that this approach should be maintained. In doing so, it recognizes that, with the limited funds available, the program can be expected to act only as a catalyst in stimulating research in the broad areas indicated in the guidelines, for which there is still an urgent requirement.

IV. REFERENCES CITED

Ontario Pesticides Advisory Committee. 1974. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1973-74. 33 p.

1975. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1974-75. 36 p.

1976. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1975-76. 42 p.

1977. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1976-77. 40 p.

1978. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1977-78. 39 p.

1979. An assessment of pesticide research projects funded by the Ministry of the Environment through the Ontario Pesticides Advisory Committee, 1978-79. 42 p.

APPENDIX I. Format of advertisement inviting applications for research support from the Ontario Pesticides Advisory Committee, 1979-80.

January 1979

APPLICATION FOR RESEARCH SUPPORT

The Ontario Ministry of the Environment has a limited amount of funds available for 1979 to sponsor research aimed at: 1) determining potential environmental hazards associated with pesticides currently in use; 2) developing alternative pesticides for those deemed environmentally hazardous and thus restricted in use; and 3) developing alternative approaches to pest control in order to reduce total pesticide input into the environment. Preference will be given to proposals yielding results in a relatively short time with funds being committed on a yearly basis. Research should be in the context of normal use patterns.

The Ministry invites research proposals in the following areas:

1. Economics of pest control including economic threshold levels of pests.*

2. Studies leading to registration of environmentally acceptable pesticides.

3. Reduction of pesticide use through development of effective pest monitoring techniques; alternative integrated or non-chemical methods of control; or improved application techniques.

4. Studies on the persistence, fate, and biological significance of pesticides in the environment with particular reference to pesticides widely used in Ontario.

5. Development of information on time which should elapse between dates of treatment and re-entry into treated areas, and on exposure of agricultural workers to pesticides.

6. Development of procedures for safe disposal of pesticides and pesticide containers.

* In the Pesticides Act, 1973, S 1(1) 20, a "pest" means "any injurious, noxious or troublesome plant or animal life other than man or plant or animal life on or in man and includes any injurious, noxious or troublesome organic function of a plant or animal."

APPLICATION PROCEDURE

Research proposals should be submitted to:

The Chairman
Pesticides Advisory Committee
5th Floor, Mowat Block
Queen's Park
TORONTO, Ontario M7A 1A2

Applications should include the following:

1. Title of project
2. Name, address and affiliation of applicant(s)
3. Discussion of problem (Applicants applying for continuation of a grant should include a summary of previous progress)
4. Clear statement of objective(s)
5. Plan for program
6. Facilities available
7. Budget - categorize costs as: Personnel - full time and part time, equipment, supplies, overhead costs, other
8. Listing of current projects and other sources of funding
9. Curriculum vitae on principal investigator(s) (if not already on file with the Pesticides Advisory Committee).

Applications should be received by February 28, 1979

APPENDIX II. Research Projects Supported by the Ontario Pesticides Advisory Committee, 1979-80

No.	Applicant	Location	Project Title	Amount Granted
1.	Brown, R.H.	Ontario Vegetable Growers' Marketing Board	To compare herbicide application methods using three new spray designs	$ 2,500.00
2.	Cameron, R.	PCO Services	A study of the residual life of commonly used insecticides in structural pest control	6,000.00
3.	Corke, C.T. Bunce, N.J.	University of Guelph	Biological production of biphenyls and azobenzenes from chlorinated aniline residues from certain herbicides	6,000.00
4.	Dodson, J.J. Mayfield, C.I.	University of Waterloo	The behavioral effects of sublethal doses of aquatic herbicides on the rheotropic responses of rainbow trout (Salmo gairdneri)	12,000.00
5.	Edginton, L.V. Parsons, I.	University of Guelph	Bacterial speck control for tomato	6,500.00
6.	Ellis, C.R.	University of Guelph	The economic significance of potato leafhoppers in new seedings of alfalfa	10,400.00
7.	Fenton, M.B.	Carleton University	Assessment of three chemicals as control agents for bats	1,875.00
8.	Fushtey, S.G.	University of Guelph	Fate of mercurial fungicides used to control disease in turfgrass	7,800.00

APPENDIX II Cont'd....

No.	Applicant	Location	Project Title	Amount Granted
9.	George, J.A.	University of Western Ontario	Control of mosquito eggs, larvae and pupae in catch basins in Ontario with a local Planarian flatworm, Dugesia tigrina	$ 5,800.00
10.	Gilbert, F.F.	University of Guelph	Blackbird population management by population reduction	31,000.00
11.	Kaushik, N.K.	University of Guelph	Effects of insect growth regulators and of microencapsulated larvicidal agents on emergence of blackfly larvae and on non-target aquatic invertebrates	8,000.00
12.	MacNeill, B.H.	University of Guelph	The cause and control of bacterial speck in Ontario tomatoes	6,500.00
13.	Mayfield, C.I.	University of Waterloo	Diquat and other aquatic herbicides in aquatic systems	6,800.00
14.	McEwen, F.L.	University of Guelph	Insecticidal baits for control of the European earwig	6,400.00
15.	McEwen, F.L. Gillespie, T.J. Sutton, J.C.	University of Guelph	A feasibility study on pest monitoring for pests of carrots and onions	51,000.00
16.	Pengelly, D.H.	University of Guelph	The ecology of the subterranean termite, Reticulitermes flavipes in southern Ontario	7,400.00

APPENDIX II Cont'd....

No.	Applicant	Location	Project Title	Amount Granted
17.	Pfeiffer, W.C. Haack, R.	University of Guelph	An economic assessment of the costs and potential benefits of pest monitoring for selected crops in Ontario	$ 7,400.00
18.	Proctor, J.T.A.	University of Guelph	Determination of the economic threshold of insect populations on apple trees by photosynthesis	8,000.00
19.	Rowsell, H.C.	University of Ottawa	Assessment of pain and distress caused by vertebrate pesticides	14,000.00
20.	Sears, M.K.	University of Guelph	Baited insecticides for control of adult cabbage maggots on rutabagas	7,500.00
21.	Smith, R.E.	University of Guelph	A study of the production of fungal bait blocks for the attraction of termites	5,900.00
22.	Surgeoner, G.A. McEwen, F.L.	University of Guelph	The biology and control of mosquitoes and other biting flies in Ontario	50,000.00
23.	Svec, H.J. Miles, J.R.W. Harris, C.R.	University of Western Ontario	Development of effective monitoring techniques and control programs for insect pests attacking vegetables grown in the Thedford Marsh	9,000.00
24.	Tomlin, A.D.	University of Western Ontario	Feasibility of using the litterbag technique as an index of the environmental impact of soil insecticides on the soil fauna	6,000.00

APPENDIX II Cont'd....

No.	Applicant	Location	Project Title	Amount Granted
25.	Tu, C.M. Chapman, R.A. Spencer, E.Y.	University of Western Ontario	Microbial degradation of pyrethroid insecticides in soil	$ 6,000.00
26.	Wukasch, R.T.	University of Guelph	Effect of companion planting on pests in the home garden	7,000.00
			TOTAL	$296,775.00

APPENDIX III. Progress reports (Abstracts) on projects funded by the Ontario Pesticides Advisory Committee 1979-80

1. Brown, R.H. - To compare herbicide application methods using three new spray designs.

This project was funded late in the summer of 1979. Work will be completed during 1980 and reported in the 1980-81 research report.

2. Blaine, W.D., Cameron, R., and Siddiqi, Z. - A study of the residual life of commonly used insecticides in structural pest control.

A study was made of the effects of some of the more common insecticides used by the structural pest control industry on the German cockroach, Blattella germanica (L.).

Two different strains were used to carry out the tests. One strain came from the University of Guelph and had never been in contact with pesticides. The other was collected from apartment buildings in Toronto where PCO Services Ltd. had been called to do clean outs.

The chemicals tested were diazinon, Dursban(R) and Ficam(R). These were applied topically using acetone as a carrier.

A difference was found in the LD50 between the two strains of roaches. The largest difference was found with the diazinon.

3. Corke, C.T., Bunce, N.J., Stratton, G.W., and Burrell, R.E. - Biological production of biphenyls and azobenzenes from chlorinated aniline residues from certain herbicides.

A. Transformations of Substituted Anilines

The metabolite 3,4-dichloroaniline is converted to two isomeric forms of tetrachlorobiphenyls, 3,3'4,4' tetrachlorobiphenyl and 2,3',3,4 tetrachlorobiphenyl. Mass spectral analyses confirm the simultaneous production of two isomeric forms of trichlorobiphenyl and dichlorobiphenyl. Identification of the tri- and di-substituted biphenyls is in progress.

The transformations of subtituted anilines follows the order of reactivity of methoxy > methyl > aniline > 4-chloroaniline > 3,4-dichloroaniline. Substitution in the 2 and 6 positions exhibits steric hindrance. The formation of the diazonium ion, which we have proposed as a key intermediate, has been confirmed as being a strict chemical reaction in which the aniline couples with biologically produced nitrite-nitrogen.

B. Transformations of the Herbicide Glyphosate in Soils

The major soil metabolites of glyphosate have been shown to be: glycine (amino acetic acid), sarcosine (N-methyl amino acetic acid), and amino methyl phosphoric acid. We have examined the degradation of glyphosate and the three metabolites by following the mineralization pattern of

nitrogen in each of the molecules. Only 35% of the nitrogen in glyphosate was recovered in mineralized form (NH_4^+-N + NO_3-N), while 95% and 90% of the nitrogen of glycine and sarcosine was accounted for over the same incubation period. The metabolite amino methyl phosphoric acid was slowly mineralized and a maximum of 20% of the nitrogen was recovered. The patterns of mineralization of glyphosate indicate that microbial attack on this herbicide is initiated within several days, and ceases after about 10 days. Warburg studies (O_2 uptake) with soil indicate that glyphosate and glycine added at equivalent carbon concentrations to soil result in maximum O_2 uptake within two days, and that the oxygen uptake due to glyphosate is about one-third that for glycine, confirming data obtained by nitrogen mineralization studies.

C. The effect of mercuric, cadmium and nickel ion combinations on a blue-green alga.

The response of Anabaena inaequalis towards combinations of mercuric, cadmium and nickel ion was dependent upon the order of metal addition and the actual metal concentrations involved. Mercuric and cadmium ions interacted synergistically towards photosynthesis ($^{14}CO_2$ uptake) and nitrogenase activity (acetylene reduction), but resulted in mixed synergism and antagonism towards growth, depending upon the actual metal concentrations used. Mercuric and nickel ions interacted in both a synergistic and antagonistic manner, depending on the metal concentrations used, towards growth and acetylene reduction but evidenced a straight additive response towards photosynthesis. Nickel and cadmium ions interacted antagonistically towards all three assay criteria. Tri-metallic ion combinations resulted in antagonism towards growth and synergism towards photosynthesis and acetylene reduction. The pretreatment of cells with either cadmium or nickel ion protected against the toxicity of subsequently added mercuric ion. Similar results were obtained by pretreating cells with either mercuric or nickel ions prior to the addition of high levels of cadmium ion. It is proposed that the interactions observed are due to a competition between the metals for cellular binding sites.

D. Interactions of pesticides and solvents in microbial sensitivity tests.

In this study solvent-pesticide interactions were determined for two fungicides, benomyl and captan and an insecticide, permethrin, with the solvent acetone. The solvent-fungicide interactions resulted in synergistic and antagonistic effects for each fungicide, respectively, when the test organism was the aquatic fungus Pythium ultimum. The solvent insecticide-interaction was additive when tested on the cyanobacterium Anabaena inaequalis.

It was concluded that solvent-pesticide interactions must be determined to obtain a true evaluation of toxicity.

4. Dodson, J.J., and Mayfield, C.I. - The behavioural effects of sublethal doses of aquatic herbicides on the rheotropic responses of rainbow trout (Salmo gairdneri).

The rheotropic response of yearling rainbow trout to a water current simulated by moving a striped background past the fish was observed following exposure to pesticides for 24 h. The pesticides examined were pentachlorophenol (proposed as a "reference" toxicant), atrazine (technical and commercial formulation), EL-171 (technical and liquid and commercial granular formulations), Diphenoprop (technical and commercial formulation) and Dowpon (technical and commercial formulation).

Pentachlorophenol at low concentrations (0 - 1 ppm) produced increases in the frequency of no response corresponding to dosage. At 0.3 ppm all of the fish died in 3 h., whereas at 0.1 and 0.2 ppm none of the fish died in 24 h.

Atrazine (technical grade) produced no change in swimming speeds or frequencies of positive or negative rheotaxis at levels up to 5 ppm. The frequency of no response declined to zero at 10 ppm. Atrazine as the formulated product had a much greater impact on the behaviour of the fish; the frequency of negative rheotaxis increased significantly and the frequency of no response again declined to zero at 10 ppm.

EL-171 (an experimental herbicide) was examined in detail. Levels of 0, 0.1, 0.5, and 1.0 ppm of the technical grade, the liquid formulation, the solid granular formulation, the granular formulation ground to a fine powder, and the granular formulation contained in a fine mesh screen were all examined. The fine mesh screen was included to determine if direct ingestion of granular material had any bearing on the effects of the herbicide. The patterns of toxicological modification of rheotropism due to the various formulations were variable. The granular formulation had the least effect (all effects were only found at the higher concentrations). Direct ingestion appeared to play no part in the observed behaviour modification. Technical grade EL-171 produced significant variation in the frequency of positive rheotaxis and in swimming speeds.

Diphenoprop is a herbicide preparation used instead of 2,4,5-T in many applications. It was examined because of its possible entry into aquatic systems. The active ingredients are 2,4-D butoxyethanol ester and 2,4-DP. Both active ingredients were examined separately and as a combination. Only the technical grade material has been examined to date. The 2,4-D butoxyethanol ester produced a declining frequency of positive rheotaxis and an increase in frequency of no response. No fish died at levels up to 10 ppm. The other ingredient, 2,4-DP, produced very similar results, except that at 5 ppm the fish became comatose and therefore had no escape response to netting. No deaths occurred.

The combined ingredients (at 50% each) in concentrations of 0 to 0.5 ppm (less than those used for the separate ingredients) caused marked behavioural changes; the frequency of no response increased with increasing dose and the frequency of positive rheotaxis decreased.

At concentrations above 2.75 ppm many of the fish died in 5-6 h. This was dose-related and continued up to 10 ppm. This synergistic effect of two active ingredients is a new phenomenon and has many implications.

5. Edginton, L.V. and Parsons, I. - Bacterial speck control for tomato.

Bacterial speck of tomato caused by Psuedomonas tomato has become a serious problem in the 8000 hectares of processing tomatoes in Ontario. The bacteria infect pedicels causing flower drop, and delay of harvest. Also fruit infection interferes with skin removal in the processing of the tomatoes. Field plots in Southern Ontario were sprayed with various copper fungicides, dithiocarbamate fungicides and combinations thereof. Untreated check plants developed 20% infected foliage by July 12th. Plants treated 7 times with fixed coppers beginning June 14th on a 7 to 10 day cycle, receiving 15.2 and 30.8 kg/ha per season, developed 15% and 10% infected foliage respectively. Neither of the dithiocarbamate fungicides, maneb and mancozeb, had an effect on disease when used alone but each enhanced the control when used in combination with the fixed coppers.

6. Ellis, C.R. and G.W. Morris - The economic significance of potato leafhoppers in new seedings of alfalfa.

In 1979, seven fields of spring-seeded alfalfa were selected from Welland, Paris, Woodstock, Guelph and Brantford to determine the economics of potato leafhopper control under commercial production systems. In each field, a non-sprayed check area was compared with areas treated with dimethoate as recommended by OMAF for leafhopper control on alfalfa. The leafhopper populations, forage height and protein content were sampled through the season and dry weight yield and protein were determined at harvest.

Dimethoate resulted in 90% control one week post spray with adult numbers less than 0.5 per sweep.

Although plant heights were not significantly different, dry weight yields of treated plots were 13% greater than controls with a corresponding protein increase of 1.7% per sample on the first cut. On second cut alfalfa requiring a second insecticide treatment, dry weight yields of treated plots were 9% greater than controls with a corresponding protein increase of 1.5%

In 1978, a dry season, plants on some fields were ten inches higher at harvest in treated plots even without respraying. On first cut alfalfa, dry weight yields in treated plots were 32% above controls with a corresponding protein increase of 1.3% per sample. On second cut alfalfa requiring a second insecticide treatment, dry weight yields increased 57% with a corresponding protein increase of 1.7% per sample. Treated plots the following Spring had a 2.5% protein increase, 9% survival increase and 22% yield increase over check plots. Overwintering studies will be conducted again this Spring.

In 1978, caged studies were used to determine the impact of leafhopper numbers on four stages of alfalfa growth. In both 1978 and 1979, leafhoppers reduced protein yield, dry weight and plant height irrespective of development stage of plant. Overwintering and protein analysis will be conducted in the Spring.

Cost/benefit analysis for 1978 showed that for each dollar invested in control with methoxychlor four dollars were returned whereas with dimethoate eight dollars were returned.

7. Fenton, M. B., and Hurley, S. - Assessment of three chemicals as control agents for bats.

Commercial preparations of zinc phosphide (ZP TRACKING POWDER(R)), DDT (RODENTRAK(R)), and fenthion (BAYTEX(R)), and two ultrasonic repellents (URIE ONE(R); RODENT SENTRY(R)), were tested as control agents of Little Brown Bats (Myotis lucifugus) in simulated roosts.

Minimum applied amounts of chemicals causing death were determined: 15.06 mg/bat DDT, 750 mg/bat zinc phosphide. As no concentrations of fenthion caused death the highest dose tested, 28.45 mg/bat, was arbitrarily selected. Selected doses were tested for effectiveness in simulated roosts divided so as to allow the bats to demonstrate preference. 20 bats were used in each roost. Mortality after 24 hours due to DDT: 3 bats, due to zinc phosphide: 1 bat, due to fenthion: none. Initially, bats avoided DDT, but this preference was not constant. No other preferences were demonstrated.

The criterion for effectiveness of the ultrasonic repellents was initial reaction to sound - degree of avoidance. Each device was tested on 20 bats in the simulated roosts and produced no effect.

It is concluded that none of the chemicals or ultrasonic repellents are suitable bat control agents.

8. Fushtey, S. G. - Fate of mercurial fungicides used to control disease in turfgrass.

Because mercurial fungicides have been used extensively for disease control in turfgrass and recent studies have shown that there is no satisfactory substitute for control of severe snow mold disease, they are likely to continued to be used for this purpose. A project was designed to learn more about what happens to the mercury applied to turfgrass and to determine whether such practice constitutes an environmental hazard. The project was set up in 2 parts:

1. To determine accumulation of residues, both vertically and laterally from the site of application, in areas which had been treated with mercurial fungicides for many years past.

2. To monitor accumulation of mercury in an area with no previous history of mercury use but placed on a program of mercurials as the principal fungicide for disease control at the time the experiment was initiated.

Results from part 1 only are presently available. Part 2 was initiated in the summer of 1979 and will take at least 2-3 years to yield reportable results.

At one sampling site, (North Halton), with recorded usage since 1967 but known usage to be much longer (probably back to 1957), where inorganic mercurials were used exclusively for snow mold control, the results were as follows: The bulk of the residue (99.8%) was in the thatch and top 5 cm soil; the bulk of the remainder (1.8 ppm) was in the next 5 cm of soil, and near background levels below the 10 cm depth. Laterally, the bulk of the residue was within 5 m of the edge of the green down a natural drainage slope, but appreciable residue (8.4 ppm) was present in thatch at 10 m. Samples taken uphill from the green yielded considerably less residue but still appreciable (1.7 ppm) at the 10 m distance.

At the other sampling site (Mississauga), with recorded usage since the late 1940's, where inorganic mercury was used for snow mold and PMAS for summer diseases, the results were somewhat different. The samples with the most residue were from the second(5 - 10 cm) soil increment rather than the thatch, and substantial residue (4.7 ppm) was found as far down as the 30 - 40 cm increment. Higher levels of mercury were found here at the 40 cm depth than at the 10 cm depth at the North Halton site, although the total amount of residue mercury was the same (454 ppm at N. Halton and 456 ppm at Mississauga). Lateral distribution of residues was similar at both sites.

The data obtained to date are insufficient to establish whether or not the use of mercurial fungicides for disease control in turfgrass constitutes an environmental hazard.

9. George, J.A. - Control of mosquito eggs, larvae and pupae in catch basins in Ontario with a local Planarian flatworm, Dugesia tigrina.

(a) Catch Basins: For the second consecutive year the numbers of mosquito larvae were lower in catch basins with planaria than in those without. In 1979 the season's average reduction of larvae by planaria was 70%. During both seasons the greatest reduction in larvae was from late August on. Hence, planaria probably reduce the overwintering populations of adult Culex mosquitoes. As planaria capture all sizes of larvae and pupae as well, the reduction of adults is probably even greater than the recorded reduction of larvae indicates.

Planaria were found to survive in catch basins: 1) overwinter; 2) even when mosquito larvae were absent, by feeding on insects stranded on the surface; 3) indefinitely at levels of Abate(R) and Altosid(R) at least four times higher than that required to kill mosquito larvae; and 4) by remaining on the walls during the routine pumping out of catch basins. However, because of one of the following conditions, planaria did not survive in some catch basins: 1) high organic matter (sewage); 2) toxic chemicals (soap, oil or unknown chemicals; and 3) drying.

(b) Aluminum Roasting Pans: Because plastic bathing pools need to be lined with aluminum foil, 10 litre, disposable, aluminum pans were used instead. With aluminum pans a means of monitoring for the presence of planaria was devised and then tested in catch basins.

In both containers, it was found to be reliable. It is a piece of styrofoam about one inch thick and six inches square which is placed on the surface of the water. When present, planaria collect on the under surfaces of such floating objects.

A means of dispensing technical Abate into catch basins from a plaster block on a float was also devised and tested. It provided season long (July 1 - Oct. 1) control in aluminum pans and control from Aug. 1 to Oct. 1 in catch basins. Weekly bioassays of the water in one aluminum pan revealed the toxic levels of Abate to fluctuate during the test period between 2 and 8 times the LC 100 for mosquito larvae.

(c) Laboratory Tests: When varied numbers of planaria were placed in water with varied numbers of mosquito larvae for 5 day periods each planarian took an average of 9.6 larvae the first day, with an average of 3.1 each per day for the 5 day period.

The LC 50's of both Abate and Altosid for planaria were found to be 1,000 times or more, than that for mosquito larvae.

Planaria did well and multiplied normally when reared three months with only mosquito larvae or only pupae as a source of food.

Planaria can be purchased or reared and established in catch basins for $1.00 to $5.00 per catch basin. Planaria will multiply in most basins and continue to reduce Culex sp. larvae indefinitely.

10. Gilbert, F.F., Brooks, R.J., and Somers, J.D. - Blackbird population management by population reduction.

Research completed in 1979 included pilot studies on the feasibility of population control by the use of toxicants at foraging sites, the establishment of initial base line data for an environmental impact assessment of roost control should it be forthcoming and a continuation of studies on the local blackbird population and movement patterns in the Matchedash Bay area.

Starlicide(R) (Ralston Purina Co., St. Louis, Mo.) bait in the form of pelletized ground corn (1% by weight 3-chloro-p-toluidine hydrochloride) was used at two corn fields and total application averaged 22.2 kg/ha/site. No benefit was demonstrated but the pellet bait may have been to blame. Alpha-chloralose was tested on one field of 1.6 ha at a total level of 15 kg/ha. Sixty-six blackbirds and starlings (Sturnus vulgaris) in various stages of narcosis were recovered. A significant reduction in damage to the corn occurred as a result of this toxicant. It was concluded that potential existed for employment of a toxic compound at foraging sites to reduce bird damage without having a negative impact on non-target species.

Most blackbirds roosted in two major cattail sections of Matchedash Bay. Twelve other avian species were seen in the proposed roost control zone. Only black terns (Chidonias major) and long-billed marsh wrens (Telmatodytes palustris) nested in the blackbird roost. The roosting area of a large population of tree swallows (Iridoprocne bicolor) was separate from the blackbird roost and Turgitol(R) treatment should therefore have little effect on non-target avian species. Alkalinity, hardness, CO_2, dissolved O_2, and pH were determined for areas of the marsh. Benthos was also examined.

There were again shifts in the numbers of birds using the various flyways out of Matchedash Bay. Two flyway populations increased and two declined while the mean roost population was 118,000 blackbirds. Over 1500 birds were captured and tagged (56.6% red-winged blackbirds (Agelaius phoeniceus)). Foraging flocks may be shifting re individuals over time and starlings appear to be feeding on milk-stage corn. Both observations were substantiated by visual observations and telemetry studies.

11. Kaushik, N. K., and Rodrigues, C. S. - Effects of insect growth regulators and of microencapsulated larvicidal agents on emergence of blackfly larvae and on non-target aquatic invertebrates.

The research project was designed to develop safe, effective and economical methods for the chemical control of black flies and involves laboratory and field trials with insect growth regulators and new formulations of conventional larvicides. Laboratory tests were carried out in numerous flowing-water troughs at the New York State Science Service's Biological Field Station in Cambridge, New York. Field trials were conducted in streams located in the Adirondack mountains.

Ultimate instar of Simulium vittatum were exposed in the laboratory to the IGR methoprene (Altosid(R) PS-10) for 30 minutes at 7.5 deg. C. The estimated LC_{50} and LC_{95} values were 0.11 ppm and 9.5 ppm, respectively. Similar tests against Prosimulium magnum (at 11 deg. C.) indicated that it was less susceptible (LC_{50} and LC_{95}: 0.22 ppm and 19.1 ppm, respectively. Comparison of three different formulations of diflubenzuron (Dimilin(R)) at 1 ppm/30 minutes at 12 deg. C. showed that the 25% WP was more effective than either of the 25% flowable or 10% flowable (in oil) formulations. The respective corrected percentage mortalities were 50.5%, 26.7% and 31.6%. The third insect growth regulator tested this year was the juvenile hormone type compound, MV-678, from Stauffer Chemical. Preliminary tests in the laboratory with unformulated material at 1 ppm/30 minutes produced 79.3% mortality of S. vittatum late-instar larvae.

Field trials with Dimilin (25% WP) were conducted in three streams in the Adirondacks, New York. The dosage rate was 1 ppm/30 minutes at water temperatures ranging from 9.0 deg. C. to 11.0 deg. C. at the time of treatment. The evaluation of the effect on target and non-target organisms was done by sampling at regular intervals (every 2 to 4 days) with artificial substrates (polyethylene tapes and brick tiles) and by use of surber sampler, D-net, drift nets and collection of rock samples. The final counts was done at 11 to 15 days post-treatment and the reduction of the Simulium larval population in the three streams was 91.1%, 96.8% and 99.4% at distances of 837 m, 585 m and 165 m from the treatment point, respectively. Samples of non-target organisms are still to be analysed.

Laboratory tests with the microencapsulated formulation of chlorpyrifos methyl (Reldan(R)) showed that late instar larvae of Prosimulium magnum were less susceptible than those of S. vittatum. The LC_{50} was 35.5 ppm as compared to LC_{50} of 5.5 ppb for S. vittatum. Although designed to reduce non-

target problems, the tests showed that this formulation was toxic to a number of non-target stream invertebrates.

A number of newly developed larvicides were screened in the laboratory against Simulium larvae. These included microencapsulated formulations of fenvalerate and pirimiphos methyl. However, these did not give any promising results. One other formulation of pirimiphos-methyl (Actellic(R) 25% WP) may have some potential. The estimated LC_{50} and LC_{95} were 25.2 ppb and 269.8 ppb respectively. Tests with a recently developed formulations of temephos, the American Cyanamid Abate 200E, showed that there was a positive correlation between water temperature and toxicity. Exposures of S. vittatum to 0.5 ppm/10 minutes produced 0% mortality at 9 deg. C. and 100% mortality at 20 deg. C.

Under the conditions of tests the microencapsulated formulation of chlorpyrifos-methyl was found to be unsafe to non-target organisms. Based on the results of field trials, Dimilin 25% WP gave encouraging results. Altosid PS-10 was effective mainly against ultimate instar larvae of black flies.

12. MacNeill, B.H. and Pitblado, R.E. - The cause and control of bacterial speck in Ontario tomatoes.

Observations made upon commercial tomato cultivars and materials used in breeding trials indicate that there is a considerable range of susceptibility to the bacterial speck disease. To evaluate possible sources of resistance to Pseudomonas tomato, a number of greenhouse and field trials were conducted during the past summer. These involved subjecting the test plants to uniform disease pressure by artificial inoculation. Initially, a number of inoculation techniques were evaluated including the pinprick, leaf swab, leaf dip, droplet and injection methods. For large scale inoculations, a 48-hour bacterial culture suspended in water to give 10^7 cells/ml was sprayed on the foliage, especially on the undersurface of the leaves, of plants 15-20 cm in height. The inoculum was allowed to dry for 2 hours, then the plants were placed in an incubation chamber which misted for 10 sec every 15 min. over a 2-day period. Typical bacterial speck lesions developed within 6-7 days, and evaluations were made on the 10th day. An initial greenhouse screening of cultivars, using this technique, revealed a range of response from the highly resistant reaction of the cultivar Ontario 7710 to the very susceptible response of Ottawa 78 and Chico III. Field inoculations confirmed the greenhouse results: no lesions appeared on either the leaves or fruits of Ontario 7710; in contrast C-28, which is generally considered as resistant in the field, had an average of 2 lesions/leaf with 25% infected fruit, and the very susceptible Walter had an average of 6 lesions/leaf and 58% infected fruit.

Subsequently, 11 of the cultivars which make up the background of Ontario 7710 were evaluated, and all but one, Farthest North, were susceptible. The latter cultivar was originally derived by A.F. Yeager of the North Dakota Agric. Expt. Sta. from a cross of Bison x Lycopersicon pimpinellifolium. Since Bison was susceptible in our tests, it appears that the resistance of Farthest North, and of Ontario 7710 comes from Yeager's

accession of L. pimpinellifolium. Sister lines of Ontario 7710, namely Ont. 7611 and Ont. 782, were also found to be resistant to bacterial speck. In addition, Oregon Cherry and Early Cherry, with Farthest North in their ancestry were resistant.

As well as the relative of Ontario 7710, 210 cultivars and breeding lines were evaluated; of these, 40 showed a high level of resistance to bacterial speck.

The possibility of transferring this resistance by backcrossing with commercial cultivars, and thus making bacterial speck resistance more generally accessible to the agricultural industry is currently under study.

13. Mayfield, C.I. - Diquat and other aquatic herbicides in aquatic systems.

The fate of the herbicide, diquat, applied to laboratory and small-scale field systems has been examined. The rates of loss from various components of the system, photolytic rates, adsorption kinetics, decomposition rates and sediment migration properties have been established in the laboratory experiments and have been used to develop and test a simulation model for diquat in those systems. With this model as a basis, preliminary trials of the herbicide in small-scale field trials have been started. The model system is based on a modelling language called "Dynamo" which simulates the operation of continuous as opposed to discrete event systems.

The first results from the field trial experiments indicated that the model for diquat was appropriate and applicable to field systems and the observed results showed a high degree of correlation between predicted and observed levels of diquat in the trials. A more comprehensive model incorporating more features and reactions has been developed from the data obtained from the field and laboratory trials and will be applied to further field trials of diquat and also to trials using the herbicide, 2,4-D in aquatic systems.

14. McEwen, F.L. - Insecticidal baits for control of the European earwig.

Progress was made in developing a culture method for earwigs under laboratory conditions. Further research is planned in 1980.

15. McEwen, F.L., Gillespie, T.J., Sutton, J.C., Liu, H.J., Dzikowski, P.A., and Hildebrand, P.

(a) Monitoring for pests of onions and carrots

In 1979, a monitoring program for insect and fungal pests of onions and carrots was established on 14 farms in the Holland, Cookstown and Keswick Marshes. It determined the presence or absence of a pest, assessed the size of its population, and thus its potential for causing damage and economic loss. Its design was based on the biology and ecology of the host plants and their associated pests. Onions were sampled to determine levels of onion maggot flies (Hylemya antiqua), leaf blight (Botrytis squamosa) and downy mildew (Paranospora destructor). Carrots were checked for carrot rust fly (Psila rosae) and leaf spots caused by Alternaria dauci and Cercospora carotae.

As well as leading to management recommendations to co-operating growers, the information formed the basis of spray recommendations against these pests for the entire Holland Marsh and associated Marshes, and was available to all growers through the Muck Research Station (OMAF).

Adults of H. antiqua were collected on sticky traps and in interception traps, which were checked daily. Dissection of females and classification of their reproductive systems with respect to stages in egg production, proved useful in determining to which generation flies belonged, especially when their numbers were low. First generation adults were encountered when 280 day degrees had accumulated above the developmental threshold (4°C) in the air, 2nd generation at 934 days degrees, and 3rd generation at 1369 day degrees. Adulticide sprays for 1st generation were not recommended where sufficient granular insecticide had been applied at seeding, regardless of numbers of flies. Sprays for 2nd and 3rd generations were recommended where fly populations increased. They were timed to coincide with the commencement of oviposition. The growers on the monitoring program who sprayed 2-3 times during the onion-growing season incurred no more maggot damage than growers on a calendar-timed schedule who applied 7-11 sprays.

Scouting for B. squamosa commenced in the first week of July and growers were alerted when the disease was spotted. The weather in 1979 was warm and wet, and conducive to the development of onion leaf blight. Growers who were applying the recommended fungicides were advised to spray every 5-7 days, and continue until their onions lodged. Severe disease was encountered in all Marshes wherever the schedule was broken. Onion fields were checked thoroughly for downy mildew, starting in late August. This devastating disease was encountered in 2 locations in the Cookstown and Holland Marshes, and was not found in the Keswick Marsh.

Sticky traps for P. rosae were installed in carrot fields and roadside trees in the spring, and were checked 3 times per week. This insect was not found in the Kewsick Marsh. In the Holland Marsh, it was most numerous along the North Canal Bank Road and at the Muck Research Station. Although a granular insecticide was applied at seeding, adulticide sprays were recommended whenever numbers of flies of the 1st and 2nd generations were on the increase. Checks for A. dauci and C. carotae on carrots commenced in late July and growers were notified when either was encountered. Weekly fungicide sprays were applied into October.

The monitoring program was successful in decreasing pesticide input without sacrificing yield and quality of the products.

(b) Weather-timed fungicide applications to control Botrytis onion leaf blight.

Plots of onions (Autumn Spice) were established at the Muck Research Station, Kettleby, Ontario in 1979. A weather-based index, accumulated after the onions reached the four leaf stage, was tested as a spray initiated criterion. There were five treatments each replicated four times: 1) no fungicide; 2) Bravo(R) applied at 10 day intervals beginning July 9; 3) Bravo applied before rainfall forecast to occur after the expiry of the manufacturer's recommended interval, beginning when the index reached 70; 4) same as treatment 3 but beginning at index of 100; 5) same as treatment 3 but beginning at index of 130.

Spray Program	Spray Initiation	Boytrytis Lesions/Leaf at Start Date	Boytrytis Lesions/Leaf on 29 August	Yield Tonnes per ha	No. of Fungicide Sprays Applied
1		-	195	44.1	0
2	9 July	0.5	2.6	42.4	5
3	19 July	2.5	9.2	43.3	4
4	25 July	7.9	6.7	45.4	4
5	1 August	9.1	7.6	47	3

Yields were not significantly different but each of the weather-timed and even the non-sprayed treatment had higher yields than the regular spray treatment, which received 5 applications of Bravo. The highest yield was from the treatment which started last and received only 3 applications of Bravo. These findings suggest that weather-timed fungicide applications commencing at about 5 to 10 Botrytis lesions per leaf or 1 to 2% leaf area diseased on an index of about 100 provide good control of Botrytis leaf blight, good yield and reduced fungicide usage.

(c) Timing Ridomil(R) in management of onion downy mildew

Downy mildew of onions recently was destructive in the Cookstown Marsh and persists in the Holland Marsh. Because the disease is explosive and destructive it must be accounted for in minimal spray programs in onions. Adequate information on relationships of weather to disease outbreaks is needed as a partial basis for timing fungicides such as Ridomil.

Onions were grown at Arkell, Ontario in mineral soil amended with mushroom compost and kept moist by trickle irrigation. In one plot area, disease progress, temperature, rain, leaf wetness duration, relative humidity, wind speed, and bright sun were monitored continuously. Four pots of infected onions served as the initial inoculum. Disease progressed until all foliage was destroyed. Analyses of data arein progress.

In the second plot area, onions in replicated plots received 0, 1 or 2 applications of Ridomil. The first application was timed to precede predicted appearance of disease. Predictions were based on sporulation in onions that served as initial inoculum, and weather factors. The second application was 12 days later.

Table 1. Effects of Ridomil on progress of downy mildew in onions.

Ridomil applications		% plants with sporulation				
Dose (kg a.i./ha)	Dates	13 Aug.	21 Aug.	25 Aug.	27 Aug.	31 Aug.
0	-	1	35	78	100	100
0.25	9/8	0	4	26	63	100
0.25	9/8 and 21/8	0	3	4	14	24

Even though the disease outbreak was late in onion development, bulb diameter was 0.4 cm greater in treated than in non-treated onions, and the proportion of grade A onions was increased significantly from 71% in the checks to 77 and 81% in onions given 1 and 2 foliar sprays, respectively. These data indicate that two applications of Ridomil controlled downy mildew in onions exposed to extraordinarily high inoculum doses, and under very favorable weather. Onion bulbs will be analysed for residues of Ridomil.

16. Pengelly, D.G., and Husby, W.D. - The ecology of the subterranean termite, Reticulitermes flavipes in southern Ontario

A surveillance of field colonies of Reticulitermes flavipes (Kollar) was maintained from April 26 to September 26, 1978 at sites in Guelph, Fergus and Leamington, and from May 3 to October 6, 1979 at sites in Guelph, Fergus and Elora.

The beginning of termite activity in the upper two feet of soil was first noted on April 26 of 1978 and on May 3, 1979. Termites remained active in the upper soil layers and in dead trees until September 26, 1978 and October 6, 1979, after which they were found only in the soil at depths from 1.0-1.3 meters. Sites were sampled at biweekly intervals at which time whole colonies were collected from infested areas.

Seasonal changes in the proportions of castes within these field colonies were investigated. Mass dispersal flights of the alate casts were not observed in either 1978 or 1979. Only small numbers of alates, representing a maximum of 0.08% of the colony from which they were collected were present in colonies collected in June, 1978. However, much larger numbers of alates, from 5-10% of the colony, were found in some colonies collected in early June of 1979. Large numbers of supplementary reproductives, eggs and early instar young were present in colonies only in the late spring and early summer in both years (from June 15-July 14, 1978 and from June 12 to July 12, 1979). No reproductives or eggs were found in colonies collected after July 14, 1978. However, small numbers of eggs and single, supplementary reproductives

were found in several colonies collected in August and early September in 1979.

Termites collected at different times of year from the field were established in laboratory colonies. Those collected early in the season showed a low viability with less than 50% colonies that were started from termites collected in May surviving for more than three weeks. Lab colonies containing groups of termites collected after the end of May showed a much higher viability. In over 90% of these colonies, the termites took readily to the nest medium and continued to survive and even to reproduce indefinitely. The inability of the termites collected in spring to establish themselves in the lab colonies suggests that Reticulitermes flavipes colonies were heavily stressed over the winter and were unable to handle the additional stress put on them by laboratory conditions.

A major problem encountered in the studies of seasonal development of colonies was in the identification of age groups. Reticulitermes could develop through nine instars. Measurement and analysis is being undertaken to develope criteria for the easy identification of these instars. The data on seasonal development of colonies indicate that Reticulitermes flavipes in Ontario has a highly adapted life cycle that allows this species to survive the fairly rigorous climate of southern Ontario. Egg laying is done predominantlyin the late spring and early summer. By the fall, the new progeny of the year have developed through to the late instars which require no specialized care from other members of the colony and are better able to withstand winter conditions. At the onset of colder weather in the fall, the colony moves deep into the soil where temperature variation is reduced. The colonies remain deep in the soil until the onset of warmer weather in the spring.

Several investigators believe that the Canadian and northern United States population of R. flavipes could well represent a separate cold-adapted race or sub-species. This study indicates that the termite population in Ontario is well adapted to our temperate climate, with a long, often severe winter. There is no reason to believe that R. flavipes will not continue to spread throughout southern Ontario. This species may be able to adapt to even more rigorous climatic conditions and extend its range northward beyond the northern limit at Kincardine. It is important that this be taken into consideration by town planners in Ontario, and that suitable anti-termite and termite-proofing building codes be written and followed in at least southern Ontario. Because of the cryptic nature of termites, their ability to survive in natural surroundings in Ontario, and the great abundance of natural wood in the environment, it is very unlikely that termites can be eradicated from Ontario.

17. Pfeiffer, W.C., Haack, R., and Stemeroff M. - An economic assessment of the costs and potential benefits of pest monitoring for selected crops in Ontario.

This project was initiated in the summer of 1979 solely sponsored by the Pesticides Advisory Committee. The project is designed as a program of research leading to a Master of Science degree at the Ontario Agricultural College. Mr. Stemeroff was named as the researcher under the supervision of W.C. Pfeiffer. Data was collected from growers of onions and carrots in the two marshes using two separate methods. A calendar, which could be hung on the

barn wall and used to record spray information "as it happened" during the season, was mailed to 145 growers. Returns from this calendar are now coming in and the co-operation of the growers is excellent thus far. During the three months from September to November, personal contact was established with 30 growers and a data sheet developed which could serve to record production data (costs, returns, equipment used, storage system, marketing strategy, etc.). Return visits have been made repeatedly to 30 "representative" growers. From these interviews a detailed set of data now exists describing the operation of their enterprises during 1979. This information, combined with existing OMAF data, is now being compiled into two "model" farms with budgets to indicate the cost per acre and the cost per unit of onion and carrot production, measured in "replacement" cost figures. Variation in costs have been observed owing to size and style of operation. Sensitivity of these farms' net returns to variation in yields, market prices, major input costs and managerial behaviour is also under investigation.

In March, these figures will be taken back to the growers and will provide the basis for three separate "focus group interviews" to validate their accuracy. The validated sets of production data will be used to assess the impact that pest management can potentially make on the costs of producing onions and carrots. Finally the pest monitoring component of pest management will be valued according to the share of these potentials which accrue to monitoring itself.

In conjunction with the traditional cost analysis, grower attitudes associated with the general concept of "pest management" and its related topics will be recorded. This will be included in the same focus group interviews. The various attitudes held by individual growers to management concerns will have some affect on their responsiveness to change, such as the introduction of pest monitoring.

The project is scheduled for completion in mid-1980. Some preliminary results arising from the data collected thus far are as follows:

1. Without exceptions, growers personally contacted have expressed "guarded optimism" about present pest managment research.

2. Acceptance of any pest management program, different from traditional chemical pest control, is conditional on two economic aspects, namely:

   a) It must be shown that a potential for cost savings exists and,
   b) That <u>risk</u> of losses due to pest infestations does not increase.

3. The approximate replacement value of a 40 acre farm on the Holland Marsh appears to be roughly $500,000.00. As a consequence of this high cost, prevailing interest rates and unstable production prices, few farms can change ownership except for "in family" transfers and for large farms incorporating smaller ones to build larger enterprises. This latter trend is rising.

18. Proctor, J.T.A., Bodnar, J., and Laing, J.E. - Effects of the tentiform leafminer on the physiology of the apple leaf.

The spotted tentiform leafminer, Lithocolletis blancardella, is today the most serious pest of apples in Ontario. While it damages leaves directly and not fruit, there could be deleterious effects on factors such as leaf photosynthesis, stomatal conductance, nutrient balance and leaf chlorophyll content. A measure of the magnitude of these factors in infected leaves could be useful in determining an economic threshold for this insect. The research approach taken in 1979 was to study the above factors on McIntosh apple trees in University and commercial orchards and to initiate complementary laboratory experiments.

At low leaf mine numbers and reduced photosynthetic area, specific leaf weight, SLW, (dry weight per unit leaf area, which is correlated with net leaf photosynthesis) increased indicating a compensating effect of the leaf/tree. At higher mine numbers (6 to 8) the SLW decreased.

Orchard measurements of leaf stomatal conductance showed a reduction of about 25 per cent with one mine per leaf and over a range of high light intensities. Stomatal conductance for unmined (control) leaves ranged from 1.90 to 2.60 mm s^{-1}.

Spur and shoot leaves from the interior and exterior of the tree with different mine populations were analyzed for nitrogen, potassium, calcium and magnesium. Totals for the 4 nutrients expressed on a dry weight basis varied with leaf type and location, but within each location highest values were obtained at one mine per leaf.

From the above initial results it appears that, although the presence of low populations of the tentiform leaf miner alters the physiology of the leaf, it is only at higher populations that these alterations are detrimental. Future studies will use the abcve approach to define a threshold population for economic control of this pest.

19. Rowsell H.C., Ritchie, J., and Cox, F. - Assessment of pain and distress caused by vertebrate pesticides.

Our knowledge that animals feel pain is based both on practical observations and scientific basis. It is easy to appreciate that an animal is in distress when it is observed to be vocalizing, shivering, panting, demonstrating escape activity or defensive aggression, or showing avoidance behaviour of a food, enclosure or area in which it had previously eaten or appeared to be behaviourally comfortable.

More recently, the scientific basis of pain and distress has produced rapid advancement of knowledge. First, the opiate receptors were demonstrated. These structures possessed by vertebrate animals dampen pain signals to the brain and spinal cord. Enkephalins, endorphins and P substance have since been demonstrated as having significant roles in diminishing pain or identifying painful responses to brain cells. Unfortunately, practical techniques are not available

to scientifically measure an animal's opiate receptors, enkephalins, endorphins or P substance. Therefore, pain and distress continue to be measured using techniques employed in this study: behavioural response, production of unconsciousness, and through electroencephalogram tracings.

The following vertebrate pesticides were studied: Red Squill; those containing anticoagulants - Difenacoum, Brodifacoum, Chlorophacinone and warfarin; zinc phosphide; Vacor;and Avitrol (4 amino-pyridine), a repellent for birds.

The basis of a vertebrate pesticide fulfilling the requirements for a humane death was a short lag phase, that is the time clinical signs of illness were produced to unconsciousness and death. The best results were those produced by the anticoagulant group of pesticides, particularly the newer short acting anticoagulants. None of the anticoagulants produced joint hemorrhage (hemarthroses) which would have produced intense pain. Red Squill and zinc phosphide produced visible distress. Vacor produced an ascending posterior paralysis which appeared distressful in the rat. Additional study is essential.

Avitrol produced convulsions with CNS depression, the EEG changes being consistent with those produced by dissociative anaesthetics. Our test procedures indicate birds are not knowledgeable of their behavioural distress. Nevertheless, it would be difficult to have the general public accept the visual display of affected birds.

As concerned human beings in a day when there is much discussion concerning animal rights and humane treatment of animals, the vertebrate pests and predators should not be regarded as second class animals. They deserve the same criteria of a humane death demanded for domestic animals, unwanted dogs and cats, laboratory animals and fur bearers.

20. Sears, M.K., and Dufault, C.P. - Baited insecticides for control of adult cabbage maggots on rutabagas.

Laboratory and field bioassay experiments were performed to determine the optimum combinations of insecticide and nutritive bait materials that could be used in a control program directed against the cabbage maggot fly.

LD_{50} values derived from microapplication of various insecticides to 3-day-old flies indicated that naled, dimethoate, parathion and permethrin were highly toxic to adult flies (LD_{50} = 2-6 ppm for 1.0 ul droplets) while diazinon and fenthion were less toxic (LD_{50} >12 ppm). The attractiveness of selected nutrient-bait materials was determined by presenting flies with blotting-paper strips soaked in six different materials and comparing the number of flies feeding on each. Yeast hydrolysate and sucrose elicited the greatest feeding response. These bait materials were mixed with the most promising insecticides and presented to flies to measure their combined attractiveness. Flies fed as actively on parathion mixed with sucrose as on sucrose alone. However, combinations of sucrose plus dimethoate, permethrin or diazinon elicited progressively less feeding.

In field bioassay experiments, rutabaga foliage was treated with naled, parathion and diazinon at 0.25 kg ai/ha, permethrin at 0.13 kg ai/ha, and dimethoate at 0.5 kg ai/ha. Flies were caged on the foliage on days 0, 1, 3, 5 and 7 following treatment. Dimethoate produced significant mortality compared with the unsprayed check for up to 5 days while parathion was effective for up to 3 days. All other treatments provided a shorter duration of effect. Sucrose at 1.0, 3.2 and 10.0 kg/ha in combination with parathion at 0.25 kg ai/ha appeared to increase mortality only on the day of treatment. In another experiment, no enhancement in mortality to caged flies was observed when sucrose, yeast hydrolysate, or skim milk at 1.0 and 10.0 kg/ha were added to parathion at 0.125 and 0.5 kg ai/ha.

Twenty-five thousand cabbage maggot pupae were placed at planting time in each of six isolated 0.13 ha rutabaga fields, subsequent infestations being monitored with yellow sticky traps. Treatments were applied on three occasions, each time there being two fields sprayed with insecticide, two with insecticide plus a bait, and two left untreated. On two occasions, parathion at 0.25 kg ai/ha reduced the number of flies caught for two and three days respectively, whereas parathion at 0.25 kg ai/ha plus sucrose at 5.0 kg/ha reduced the number of flies for one more day in each case. Dimethoate at 0.5 kg ai/ha and dimethoate at 0.5 kg ai/ha plus sucrose at 5.0 kg/ha both reduced the number of flies caught for seven days.

21. Smith, R.E. - A study of the production of fungal bait blocks for the attraction of termites.

Introduction: In 1961, Esenther et al. demonstrated that an extract obtained from wood infected with a fungus was more attractive to termites than sound wood (1). Seven years later, the trail-following pheromone of southern subterranean termites was isolated, and its chemical structure was determined (2). Shortly after, it was shown that the pheromone was closely related to a component of an extract wood infected by the fungus Lenzites trabea (Gloeophyllum trabeum), which accounted for the attraction of G. trabeum-infected wood to termites (3). Since then, the attractant has been synthesized.

A number of investigations regarding termite populations have involved the use of G. trabeum-infected wood as "baits" to facilitate sampling various soil sites for termites and also in an attempt to use poisoned baits for termite control. The present investigation was undertaken to determine if more efficient methods of production could be designed, and superior baits produced. Four objectives were established.

Interim Results:

Objective 1): To improve the rate of wood decay and growth of G. trabeum to reduce the time required for bait production.

This investigation involves an attempt to produce fungal baits on a relatively large scale, using wooden strips in association with culture media, in place of small wood blocks in soil culture. Optimum conditions for fungal growth have been established and a technique using pine strips in contact with an agar culture contained in teflon-lined cake pans is being evaluated. Results to date indicate that the incubation time required for bait production cannot be significantly reduced, but improved production efficiency appears probable.

Objective ii): To improve yields of the fungal product responsible for attracting termites.

Plans for this section of the work were made on the basis of results reported by Howard et al. in which pheromones were identified by thin layer chromatography. This technique appeared ideally suited to the screening of large numbers of culture extracts during trials designed to improve yields of pheromones by fungi. Although we have been able to detect chemical markers by this method, we have been unable at this time to make quantitative estimations of the fungal attractant. Gas chromatographic methods which could be used are not suitable for screening large numbers of extracts because of time and cost constraints. Unfortunately, attempts to obtain samples of the pheromone-like attractant from other investigators have not been successful. For these reasons, we have been forced to rely on the use of biological assays, based on termite response. The outcome of these is often confused, and results are sometimes impossible to interpret. However, we have not given up on this problem, and efforts to evaluate pheromone yield are continuing. We are also examing other products which result from the degradation of wood by fungi for possible attractiveness to termites.

Objective iii): The assessment of fungi other than G. trabeum for the production of fungal baits.

A small collection of brown rot fungi is presently being made, and these organisms will be compared to G. trabeum as agents for termite bait production.

Objective iv): The use of substrates other than wood blocks for bait production.

Fir, spruce, pine and oak have been compared as substrates for termite bait production, using G. trabeum. Pine appeared to be superior to the other types of wood, and has been used throughout the investigation. We are now examing the possibility of using sawdust and other cellulosic materials as alternate substrates.

22. Surgeoner, G.A., Helson, B.V., and McEwen, F.L. - The biology and control of mosquitoes and other biting flies in Ontario.

(a) Evaluation of synthetic pyrethroids for the control of mosquito larvae and pupae.

In 1979, the effectiveness and potential environmental impact of the synthetic pyrethroids, fenvalerate, cypermethrin and permethrin were evaluated by monitoring invertebrate populations after treatment of natural, snowmelt pools and by comparing the toxicities of these compounds to fish and mosquitoes in simulated and field pools. The relative efficacies of various formulations were also compared both in the laboratory and in simulated pools.

In 2 natural pools, fenvalerate provided better than 95% control of Ae. stimulans larvae and pupae at 15 g/ha. With the exception of copepods, most non-target insects and crustaceans were greatly

reduced (>90%). None were completely eliminated in the pools. Cypermethrin also provided 99% control at 20 g/ha. However, at 10 g/ha the overall larval and pupal mortality was only 86% primarily because of pupal survival. Cypermethrin caused large reductions in non-target insect poplulations but with the exception of amphipods, little effect was observed on crustaceans.

In simulated pools, cypermethrin caused no fish mortality at effective dosages for mosquito control whereas fenvalerate exhibited no safety margin to sticklebacks at such dosages. At dosages effective for larval control permethrin caused no fish mortality but 100% mortality occurred at dosages required for pupal control. Pyrethrins + piperonyl butoxide were also tested for comparative purposes. They exhibited no safety margin at effective larviciding dosages.

As in 1978, the technical materials were again more toxic than the corresponding EC formulations in laboratory susceptibility tests. Similarly, in simulated pools, technical cypermethrin and fenvalerate in acetone were more effective than the EC formulations. The order of effectiveness of our permethrin formulations was technical > oil > EC > WP.

In conclusion, cypermethrin is the most promising synthetic pyrethroid tested to date for the control of mosquito larvae and pupae. Formulation improvements could increase the efficacy of these synthetic pyrethroids for mosquito control.

(b) Dosage requirements of temephos relative to temperature and larval age of Aedes sp. mosquitoes.

As in 1978, the susceptibility of spring Aedes larvae to temephos varied with water temperature and larval age. In laboratory tests first instar larvae at 19 deg. C were 37-fold more susceptible than 4th instar larvae at 4 deg. C. Mean 24-hr LC50 values were 0.5 ppb and 18.5 ppb respectively. The mean 24-hr LC90 value of 70.5 ppb for fourth instars at 4 deg. C is ca 4 times greater than the maximum concentration of temephos currently recommended (18 ppb) for Aedes control. By contrast the value of 0.76 ppb for first instars at 19 deg. C is ca 8 times less than the minimum concentration currently recommended (6 ppb).

Tests in simulated leaf litter pools under field conditions showed similar relationships. After 24 hours, concentrations of 5 ppb were required to give ca 90% control of 1st and 2nd instar larvae at warm water temperatures (mean 14 deg. C and 22 deg. C in 2 tests) while concentrations of 50-100 ppb were required with 4th instars at cool temperatures (mean 7 deg. C in 2 tests). However, in both tests against 4th instars at cool temperatures mortality increased with time so that by 72 hr effective control was achieved at 10 ppb. Similar time-dependent increases in mortality were observed in two laboratory tests with fourth instars at 4 deg. C.

After 72 hr, the mean LD90 value was 10.3 ppb as compared to the 24-hr LC90 of 50.C ppb.

In conclusion, recommended dosages of temephos should provide satisfactory control of Aedes larvae of different ages over a wide range of water temperatures but such control may not be evident until several days after treatment of late instar larvae at cool temperatures.

(c) Research on backyard mosquito control in 1979

In 1979, granular area repellents, residual permethrin treatments, insect repellent lawn sticks and several fogging compounds were evaluated for backyard mosquito control.

Mosquito Beater(R) and Mosquito Chaser(R) were evaluated as area mosquito repellents in backyards at a dosage of ca 3.5 lb product /5000 sq. ft. These materials are granular formulations with methylated naphthalenes (fumigant) and 2 mosquito repellents as the major active ingredients. In 4 trials, total reductions in numbers of females landing on forearms ranged from 48-62% during the evening of treatment. In a fifth trial no reductions occurred perhaps because of windy conditions for 2 hours following treatment. In 3 of these trials little residual activity (13-37% reduction) was present the following evening.

Residual application of permethrin on grass and shrubs at 0.7 g ai/100 sq m (at present prices, $0.35/100 sq m) was also evaluated for backyard mosquito control. In 4 trials, reductions ranging from 43-88% (mean 75%) were observed the evening of treatment and in all cases the maximum number of mosquitoes biting in a minute (0.2-0.7) was below the arbitrary annoyance level of 1 mosquito/ minute. Residual activity remained at ca 70% or more for 2-3 evenings following treatment but usually declined on and after the fourth evening. Rainfall usually preceded these declines.

Bug-Away(R) insect repellent lawn sticks were also evaluated for mosquito control in backyard situations. These sticks contain pyrethrins + piperonyl butoxide and burn slowly when lit emitting smoke which supposedly repels mosquitoes within a 20 ft. radius. They are similar to mosquito coils. In 3 trials, no appreciable reductions were evident when the sticks were burning. A mean of 46 mosquitoes were caught when a stick was burning compared to 48 without a stick.

Finally, several insecticides were evaluated against caged Culex sp. females for their potential as fogging compounds in backyard situations. With a propane fogger both permethrin and azamethiphos as 0.25% and 1% oil solutions respectively gave 90-100% control at .09 and .18 g ai/100 sq m. Propoxur 1% at .31 g/100 sq m gave only partial control (47-65%) with

either a propane fogger or mist blower. Resmethrin 0.2% at .07 or .14 g/100 sq. m provided 94-100% control when applied with a mist blower but only 70-73% control with a propane fogger indicating thermal degradation.

In conclusion, residual permethrin treatment is the most promising method of backyard mosquito control tested during the past 3 years providing significant relief for several days following treatment. Granular area repellents can provide partial relief the evening of application. Bug-Away(R) lawn sticks were not effective. Permethrin, azamethiphos and resmethrin (as a cold fog) exhibited good potential as fogging compounds for backyard mosquito control.

(d) Oviposition sites as a method for monitoring Culex sp. populations.

Four types of containers, plastic pails (A), plastic tubs (B), galvanized metal tubs (C) and children's wading pools (D) were compared as oviposition sites for their relative effectiveness in monitoring Culex sp. populations. Four replicates of each site were set up in a latin square design, lined with sod and filled with 6-8" of water. Over the season mean, numbers of egg rafts ranged from 43 in A to 588 in D and were strongly correlated with surface area ($r = 0.996$). Forty-five to 55% of the rafts were Cx. pipiens in B, C and D whereas A had only 20%. Weekly variations in number of egg rafts was highest in A (50%) followed by B (24%), C (20%) and D (18%) but seasonal patterns were similar in all.

Of the 4 containers tested, wading pools would be the most efficient for monitoring Culex sp. populations because of the large number of rafts collected with low variability. Metal tubs and plastic tubs would be satisfactory if a more portable site was required although their accuracy is less than that of wading pools. Plastic pails would not be suitable because of their high variability and bias towards Cx. restuans egg rafts.

Four children's wading pools were also set up in the Guelph area to evaluate their effectiveness as oviposition sites in different localities. During the season a mean of 899 ± 159 (SE) egg rafts were collected with an average weekly variation of 17.5% between pools. Seasonal patterns between pools were similar and these corresponded closely with that of a New Jersey light trap used to monitor adult female populations. In conclusion, children's wading pools are an efficient, practical and selective method for monitoring populations of Culex sp. mosquitoes. The results are available immediately and require no entomological expertise to obtain.

(e) The bionomics of Culex pipiens (L.) and Culex restuans Theobald in relation to control. (D.J. Madder).

Populations of Culex pipiens and Culex restuans were monitored throughout the 1979 season by determing the number of egg rafts laid in a series of nine artificial pools at the University of Guelph and a variety of sites throughout the Guelph region. Data from all sites indicate that Cx. pipiens had three to four major generations (first oviposition May 11, last oviposition Sept. 15) while Cx. restuans had two to three major generations (first oviposition May 9, last oviposition Sept. 20). Adult fecundity of both species was found to change through the season with overwintering females showing a lower egg production than subsequent summer generations; however later summer generations show declining egg production. Field Cx. pipiens larval density studies indicate high larval density increases development time, decreases survival rate and causes a decrease in adult fecundity. Thus larval density may be a population limiting factor at very high populations levels. Cx. pipiens larval/pupal development rate and adult ovarian development were monitored throughout the season and were found to positively correlate with water and air temperatures, respectively. Air temperature was not found to affect fecundity. Field and laboratory studies concerning the induction of diapause in both species indicate that diapause is the prime factor regulating the number of generations per year, and causes the decline in the breeding population of Cx. restuans in July and Cx. pipiens in August. In the diapause state, the females are not reproductively active. These data indicate that efficient control of these species should focus on larval control in May through July.

(f) Evaluation of colour infra-red photography for municipal mosquito abatement programs.

An aerial survey of London, Ontario using colour infra-red photographs was conducted on May 3, 1978 to determine the efficacy of this technique for mapping spring Aedes larval habitats. Although the entire city was photographed, follow-up ground evaluations were conducted on ca 20 sq km of southeast London. Analysis of this area indicated 113 potential spring Aedes breeding sites as compared to 30 sites previously detected by ground surveys by municipal personnel.

On May 3, 1979, 54 sites previously detected and classified from aerial photographs were examined by ground survey. Interpretation of aerial photographs predicted 33 sites to be likely breeding habitats. Of these 25 (76%) did have larval mosquitoes. Nineteen sites were predicted not to have larvae of which 16 (84%) did not have detectable numbers. Two sites no longer existed. Thus (25/28) 89% of the water bodies found to harbour spring Aedes larvae were predicted from aerial photographs. The estimated cost of this research program including photographs of the entire city and interpretation of photographs for the test area was ca $2,000. It is recommended that colour infra-red aerial surveys should be an integral part of existing and potential municipal mosquito abatement programs directed against spring Aedes species.

(f) Evaluation of monomolecular surface films and Bay SIR 8514 for the control of immature mosquitoes.

In 1978, WP and EC formulations of the insect growth regulator Bay SIR 8514 resulted in 100% control of Culex pipiens larvae at 50 g ai/ha in simulated pools. In 1979, a 0.5% granular formulation gave similar results with 95% control at 50 g/ha. This formulation also effectively controlled 3rd instar Ae. vexans larvae within 7 days at 10 g/ha. Total mortality of 3rd instar Ae. stimulans larvae was also obtained with the EC and WP formulations at 10 g/ha, 7-10 days after treatment.

As in 1978, the monomolecular surface film, sorbitan monooleate again provided excellent control of Ae. stimulans larvae and pupae at 0.2 ml/sq m in simulated, leaf-litter pools. At 0.2 or 0.4 ml/sq m oleyl ether and isostearyl alcohol were not satisfactory pupicides and were slow and inconsistent against larvae. In a small, natural snowmelt pool, sorbitan monooleate at 0.2 ml/sq m did not effectively control Ae. stimulans larvae and pupae. Further field trials are required at higher dosages.

23. Svec, H.J., Miles, J.R.W., and Harris, C.R. - Development of effective monitoring techniques and control programs for insect pests attacking vegetables grown in the Thedford Marsh.

In the second year of this project, major emphasis was placed on development of a monitoring technique and control program for the onion maggot. Biological studies were continued. The overwintering pupal population continued to be much higher than that encountered in other onion growing areas in southwestern Ontario. Pupal counts ranged from as low as 1,210 to as high as 111,320/acre (avg. of 37,813/acr or 7.8/sq. yd.). Highest pupal counts occured in fields used for production of pickling onions and sets for seed, where large numbers of undersize (reject) onions left in the fields at harvest, sprouted in early fall. These onions attracted large numbers of flies and served as a source of food for last generation larvae. Clean fields had very low overwintering pupal counts. Emergence of flies during the growing season was followed using pupal emergence cages and flight interception cages. Adults emerging from overwintering pupae were present in the fields from mid-May until the end of June, second generation flies were present from the beginning of July until August 10, and 3rd generation from August 20 to September 30.

Crop loss estimates were obtained using large plots established on acreage rented from one grower. In the absence of insecticide treatment, onion maggots caused 1.0, 16.3 and 25.7% damage to Dutch Sets, pickling onions, and sets grown for seed, respectively. Based on yield/acre and value of the crop, potential crop loss would be $16,538, and 591/acre for Dutch sets, pickling onions, and sets for seed, respectively. Unfortunately the plot containing dry onions was accidently destroyed.

A two year study, done in microplots at the London Research Institute, to assess the effectivness of eight registered or experimental insecticides in controlling 1st generation onion maggots was completed. Fonofos, chlorfenvinphos, fensulfothion, carbofuran, ethion (all registered for use), chlorpyrifos, Amaze(R) and terbufos (three experimental materials) all

provided adequate to good control of onion maggots attacking Dutch Sets, pickling, and dry onions. These tests were done using an insecticide-susceptible strain of onion maggot. Previous studies have shown that onion maggots in the Holland Marsh have developed resistance to 3 of the 5 insecticides (ethion, carbofuran, and fensulfothion) currently registered for this use. Field trials were conducted at the Thedford Marsh. Fonofos was used in the seed furrow treatment and adulticide sprays were timed according to monitoring data. Excellent onion maggot control was obtained on all four varieties of onions as follows:

Dutch Sets: Seed furrow treatment + 5 sprays (0.1% damage vs. 1% in control).

Pickling Onions: Seed furrow treatment + 5 sprays (0.4% damage vs. 16.3% in control).

Sets for Seed: Seed treatment + 6 sprays (0% damage vs. 25.7% in control).

Dry Onions: Seed treatment + 9 sprays (0% damage).

Studies on levels of insecticide residues in Thedford Marsh soils and crops were continued. A survey of the extent to which carbofuran residues are occurring in organic soils used for vegetable production in southwestern Ontario, including the Thedford Marsh, was completed and results published. No significant residues of insecticides were found in onion samples collected from a number of farms in the marsh.

In co-operation with the Ontario Ministry of Agriculture and Food, research results were used to advise growers on onion maggot control. Research Institute staff participated in the Education Day for growers held at Thedford in March, 1979. Identification kits to assist growers in identifying onion maggot flies were made available in early May. Newsletters were sent to growers at appropriate times during the growing season advising growers when to begin spraying. In addition, Research Institute staff visited the Marsh three times each week from April to September to carry out pest monitoring and insecticide control programs. During these visits they contacted key growers and provided current information and advice. A number of growers followed the pest monitoring/control program with good results.

24. Tomlin, A.D., and Broadbent, A.B. - Feasibility of using the litterbag technique as an index of the environmental impact of soil insecticides on the soil fauna.

Nylon fabric bags (10 cm x 10 cm) of three mesh sizes, 0.005 mm (S), 0.7 mm (M) and 9.0 mm (L), which exclude soil invertebrates of different size classes were filled with a measured area of corn leaf tissue and buried (3-5 cm) in a cornfield soil. The litterbags were unearthed after various intervals throughout the growing season to measure the remaining leaf area; leaf decomposition rates based on area reduction were determined for carbofuran row-treated, broadcast-treated, and untreated control plots in 1977, 1978 and 1979. In 1977 and 1978 carbofuran 10 G was applied at the recommended rate (for corn rootworm control) of 1.1 kg AI/ha and in 1979 it was applied at 11.2 kg AI/ha.

The rapid rate of breakdown of carbofuran residue in the sandy loam soil was positively correlated with precipitation and soil moisture levels. The rate of corn leaf decomposition was correlated with mesh size: L-mesh > M-mesh > S-mesh, indicating the importance of soil fauna in mediating the decomposition process because no soil invertebrates would be admitted to the S-mesh bags. In 1977, a delay before the onset of decomposition of the corn leaf in M- and L-mesh bags, after carbofuran row-treatment, was assumed to be due to the detrimental effect of the carbofuran on microfaunal (primarily mites, springtails, and nematodes) and macrofaunal (primarily earthworms and millipedes) populations, respectively. This delay was not observed in 1978. In 1979, a short delay in the onset of decomposition of the corn-leaf in the L-mesh, after row treatment, was a result of the detrimental effect of the large dose of carbofuran on the soil macrofauna, particularly millipedes and, to a lesser extent, earthworms. No other detrimental effects on the decomposition process were observed as a result of the carbofuran treatments applied.

In parallel experiments, soil cores (15 cm deep x 5 cm) were taken from each plot on several occasions during each growing season and the resident soil microfauna extracted by Tullgren funnels. No decrease in the total number of soil microfauna was found which could be attributed to treatment effects. A decreased population of predaceous mites and an increase in non-predaceous (predominantly saprophagous and fungivorous mites) was observed up to 10 weeks after treatment. Large sampling variances within these arthropod populations obscured effects due to treatment and population trends and were not always consistent, both during the season and from year to year, which made interpretation difficult.

In 1977 and 1978, earthworm (predominantly Aporrectodea tuberculata) populations in the cornfield were not significantly different among row-treated, broadcast-treated, or untreated plots at 6 months after treatment. In 1979, worms retrieved 2 weeks after the large applications of carbofuran, had abnormal segmental swellings and pigmentation. Dead millipedes (predominantly Cylindroiulus caeruleocinctus) were found on the soil surface of the row- and broadcast-treated plots 2 weeks after the 11.2 kg AI/ha treatment.

A cost/time analysis of the litterbag method versus the soil core method showed the former method allowed simplified data analysis and interpretation, and required minimal taxonomic expertise compared to soil core analysis. The litterbag technique has been demonstrated as a practical approach to assessing pesticide effects on the decomposition process in soil.

25. Tu, C.M., Chapman, R.A., and Spencer, E.Y. - Microbial degradation of pyrethroid insecticides in soil.

The role of microorganisms in the degradation of the pyrethroid insecticides fenpropanate, permethrin, cypermethrin, fenvalerate and decamethrin was examined by studying their persistence in sterilized and natural soils over 16 weeks. Persistence was greater in the sterilized soils for all insecticides indicating that microbial degradation is an important process in their disappearance from natural soils. The rates of disappearance from

the natural soil varied suggesting the order of increasing resistance to microbial attack was fenpropanate, permethrin, cypermethrin, fenvalerate and decamethrin.

26. Wukasch, R. T. - Effect of companion planting on pests in the home garden.

Though home gardeners are interested in non-chemical methods of pest control, very little research has been conducted to test the efficacy of "organic" gardening methods. One such method, companion planting, involves interplanting crops with other plants so as to repel or somehow prevent pest outbreaks.

To assess this method on representative home garden crops, replicated field plots of potatoes, cabbage, and roses were established on land which had been out of production for several years. Despite heavy weed competition, only paper, wood-chips, and sewage sludge - leaf litter compost were used as mulches in conjunction with hand-weeding and cultivation. No commercial fertilizers except cattle manure and bone meal, and no pesticides except those applied to the sprayed plots were used in efforts to maintain the "organic" nature of the experiments.

Several herbs including wormwood (Artemisia absinthium), chives (Allium schoenoprasum), garlic (Allium sativum), sage (Salvia officinalis), thyme (Thymus vulgaris), tansy (Tanacetum vulgare), basil (Ocimum basilicum), horseradish (Armoracia rusticana), hyssop (Hyssopus officinalis), parsley (Petroselinum crispum), and peppermint (Mentha piperita); three crop plants, bean, flax, and tomato; and two ornamentals, nasturtium (Tropaeolum majus), and marigold (Tagetes erecta) were planted surrounding and within plots of potatoes, cabbage, and roses as recommended in "organic" gardening literature. Unsprayed check and sprayed plots were also included in each experiment. Pest and disease levels were evaluated weekly by visual and sweep net samples. Crop yield and quality data were also obtained.

In the potato experiment, the number of plant bugs (Miridae) and green peach aphids in any companion treatment did not differ significantly from those in the check plot. Significant control of potato leafhoppers was obtained only in sprayed plots. The number of Colorado potato beetles and potato flea beetles was too low to evaluate. Furthermore, no treatment differed from the check in yield, early blight, late blight, or hopperburn except the sprayed plots, which yielded 60% greater and sustained negligible disease or insect injury.

Cabbage pests such as the crucifer flea beetle (CFB), imported cabbage-worm (ICW), and diamondback moth were mostly unaffected by companion plants, with a few exceptions. Nasturtium attracted nearly 4 times the number of CFB recorded in the unsprayed check; conversely, marigold and wormwood apparently reduced CFB populations to levels similar to those in the sprayed plots. Sprayed cabbages had fewer pests than all other treatments. However, the ICW oviposited significantly more on sprayed cabbages than on those in any other treatment. The number of cabbage loopers, cabbage aphids, cut-

worms, and cabbage maggots was too small to warrant comparisons. Though sprayed cabbages had the highest yield and quality and the earliest harvest, these effects did not significantly differ from the check plots. Most other companion treatments also did not differ from the check. However, the competitive effects of tansy, tomato, wormwood, and marigold seriously reduced cabbage yield and marketablity.

No significant differences were observed between rose pests regardless of companion plant, except that in the nasturtium plot, nearly twice the infection of black spot (Diplocarpon rosae) and the lowest flower yield occurred. The dense, competitive growth of nasturtium may explain these effects, reducing air circulation, and depriving the roses of light and nutrients. Sprayed plots sustained no significant disease nor insect injury. No treatment significantly affected yield and quality of roses in 1979, although sprayed plots yielded the greatest number of large-sized flowers. Such differences would likely appear in subsequent years with perennials such as roses.

Few results obtained from these initial experiments substantiate popular claims that companion plants repel insects and disease organisms. However, numbers of many pest species were too low to adequately assess. In fact, often the effect of companion plants was detrimental to the crop either by attracting a pest, promoting environmental conditions which were conducive to disease development, or by reducing yield through competition. The costs of implementing a chemical spray or companion plant program were comparable, depending on the companion plant.

Research proposals funded in 1978-79 and completed in 1979-80

27. Chapman, R.A., Svec, H.J., and Spencer, E.Y. - Activity and persistence of some organphosphorus, carbamate and pyrethroid insecticides in soil.

Field microplot studies set up in 1977 to examine the uptake of furrow granular treatment of insecticides by onions from organic soil and the carry-over of the insecticides in the soil to the following year were continued. Fall residues from annual spring applications of ethion (2 lb), fonofos (1 lb), chlorpyrifos (1.5 lb), and chlorfenvinphos (1 lb) were 4.36, 1.10, 1.65 and 1.09 ppm after the first and 3.08, 1.69, 1.91 and 1.42 ppm after the third year respectively, demonstrating that they were not accumulating at the rates of application. Soils treated with carbofuran (1.5 lb)contained < 0.02 ppm for the first two years. Third year results are not available yet. Onions contained < 0.01 ppm of all insecticides at harvest and OP residues were < 0.01 ppm at three stages of growth during the third year. Third year results for carbofuran treated onions are not available yet.

Field studies on the persistence of four pyrethroids, permethrin cypermethrin, fenpropanate and fenvalerate in mineral and organic soil were continued. The residual amounts of cypermethrin and fenvalerate, 0.04 and 0.11 ppm respectively, present in organic soil 1 year after

an incorporated treatment of 4 oz/acre in 1977 were quite persistent and only declined to 0.01 and 0.05 ppm respectively during the next year. Surface applied pyrethroids were also more persistent in organic soil with 10-20% of the initial applications present after 6 months as compared with < 5-6% present in the mineral soil after 4 months. Residues in the organic soil were essentially the same in the spring (1 year after application) as they were the previous fall.

APPENDIX IV. Publications relating to Ontario Pesticides Advisory Committee Research Programs, April 1, 1979 - March 31, 1980

Chapman, R.A. and Harris, C.R. 1980. Persistence of chlorpyrifos in a mineral and an organic soil. J. Environ. Sci. Hlth. B15: 39-46

Dodson, J.J. and Mayfield, C.I. 1979. Modification of the rheotropic response of rainbow trout Salmo Gairdneri by sublethal doses of the aquatic herbicides diquat and simazine. Environ. Pollut. 18 : 147-157.

Fenton, M.B. and Hurley S. 1980. Comparison of methods used for controlling bats in buildings. Journal Wildlife Management 44 (2): 502-505.

George, J.A. 1978. The potential of a local planarian, Dugesia tigrina (Tricladida Turbellaria) for the control of mosquitoes in Ontario. Proc. Entomol. Soc. Ontario 109: 65-69 (Published 1979)

Gillespie, T.J. and Sutton, J.C. 1979. A prediction scheme for timing fungicide applications to control alternaria leaf blight in carrots. Can. J. Plant Pathol. 1: 95-99.

Kinoshita, G.B., Svec, H.J., Harris, C.R. and McEwen, F.L. 1979. Biology of the crucifer flea beetle, Phyllotreta cruciferae (Goeze) (Coleoptera: Chrysomelidae) in southwestern Ontario. Can. Ent. 111: 1395-1407.

Miles, J.R.W. and Harris, C.R. 1979. Carbofuran residues in organic soils in southwestern Ontario. J Environ. Sci. Hlth. B14: 655-661.

Rowsell, H.C., Ritchey, J. and Cox, F. Assessment of humaneness of vertebrate pesticides. Proceedings of Canadian Association for Laboratory Animal Science. Annual Meeting, University of Guelph, June 1979. (In press)

Sharom, M.S., Miles, J.R.W., Harris, C.R. and McEwen, F.L. Behaviour of 12 insecticides in soil and aqueous suspensions of soil and sediment. Water Res. In press.

Sharom, M.S., Miles, J.R.W., Harris, C.R. and McEwen, F.L. Persistence of 12 insecticides in water. Water Res. In press.

Smith, E.A.H. and Mayfield, C.I. 1978. Mobility and degradation of paraquat in soil. Water, Air, and Soil Poll. 9: 439-452.

Tu, C.M. 1980. Influence of five pyrethroid insecticides on microbial population and activities in soil. Microbial Ecol. 5: 321-327.